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Multi-Spectral Optical Observations of Sprites from SOFIA

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ABSTRACT

Some of the outstanding questions that could be addressed relate to the difference between land/ocean sprites and elves, summer/winter sprites and elves, and the relationships between TLEs and the parent thunderstorms and lightning discharges. Long-term (20 years) measurements would supply us with statistics that would allow us to address some of these questions.

INTRODUCTION

Sprites are a type of transient luminous event (TLE) generated in the stratosphere and mesosphere above active thunderstorms. In the last decade much has been learned about TLEs, but many mysteries remain. In an attempt to further understand TLE characteristics and their distribution on a global scale, the PIs of this project recently succeeded in imaging TLEs from the space shuttle Columbia during the Mediterranean Israeli Dust Experiment (MEIDEX) in January 2003 (Yair et al., 2003). Using forecasting tools to locate the most active thunderstorms (Ziv et al., 2004), the astronauts were successfully trained in imaging sprites (Yair et al., 2004) and ELVES (Israelevich et al., 2004) from space. The success of the MEIDEX sprites mission has given us confidence that SOFIA could also be used to successfully study sprites during the nighttime flights out of NASA Ames.

MEDITERRANEAN ISRAELI DUST EXPERIMENT

Unique among the events during the shuttle mission was a sequence relating meteors to sprites. When flying eastward into continental Africa over Namibia, a strong storm was observed over the Congo basin. In the span of less than 2 minutes two meteors and 4 bright TLEs were observed within the same atmospheric volume. The first meteor was observed at 01:52:47.23 UT. Based on a comparison with visible background stars we estimate this meteor to peak at magnitude +1.5. The second meteor was brighter (+1.0) and occurred at 01:53:05.32 UT (Fig.1). The image consists of 14 superimposed frames in the 665 nm (red) filter, spanning a total duration of 0.462 seconds, and shows that the meteor entered the atmosphere between the shuttle and the limb, as the earth is clearly visible in the image due to the illumination by the moon (phase 68.5%) and was seen at an oblique angle, coming in from the northeast.

The raw data obtained from the Xybion camera showed the occurrence of a triple columniform sprite, which was recorded at 01:53:15.89 UT, less than 15 seconds after the meteor penetrated that same atmospheric volume. This event was located almost directly above the limb 1900 km away from the shuttle. A subsequent image from 01:54:46.08 UT shows a carrot-shaped sprite with a distinct bright body (Fig.2) and a dimmer set of tendrils extending upwards toward the ionosphere. The proximity in time and space of the two kinds of observed events, bright meteors and TLEs, lends credit to the existing theoretical studies and may confirm the significant role that meteors play in TLE generation and evolution.

Fig. 2

In addition to the optical measurements, ELF/VLF electromagnetic observations were carried out simultaneously during the MEIDEX mission (Price et al., submitted to GRL 2004) and will also be available during the SOFIA flights. These ELF/VLF measurements can detect the EM signal from intense lightning anywhere around the globe (Price et al., 2002), and provide additional information on the parent lightning that produces the TLE.

OBSERVATIONS FROM SOFIA'S UPPER DECK

We propose continuous optical observations conducted from SOFIA at several wavelengths and in conjunction with ground-based ELF/VLF measurements. The SOFIA observation platform will allow the coverage of a significant part of the relevant atmospheric volume between heights 20 and 200 km. We therefore propose to use the back-up radiometric multispectral Xybion camera used in the MEIDEX (already space qualified by NASA) with a different set of filters (for example, a 308 nm filter to single out the OH emission), to better address the optical properties of TLEs and meteor trails. This camera will be co-aligned with a second near-IR camera with a similar field of view, thus allowing the detection of emissions at longer and shorter wavelengths. Such imaging measurements were not attempted from space as a coherent program and will provide crucial observations relevant to the understanding of meteor interactions with sprites.

The system will be designed to work autonomously and its operation will not require crew intervention. Recording of data will be triggered by a transient event, and will be downloaded to an on-board memory device that can be retrieved and replaced at a later stage.

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